Plants tag insect herbivores with an alarm

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Rooted in place, plants can't run from herbivores—but they can fight back. Sensing attack, plants frequently generate toxins, emit volatile chemicals to attract the pest's natural enemies, or launch other defensive tactics.

Now, for the first time, researchers reporting in the June 2007 issue of Plant Physiology have identified a specific class of small peptide elicitors, or plant defense signals, that help plants react to insect attack.

In this colorful self-defense strategy, proteins already present in the plant are ingested by insect attackers. Digesting the proteins, the insects unwittingly convert this food into a peptide elicitor, which gets secreted back onto plants during later feedings. Recognizing the secreted elicitor as a kind of "SOS," plants launch defensive chemistry. This defense discovery opens the door for the development and genetic manipulation of plants with improved protection against pests.

Although researchers have long known that some plants distinguish different insect attackers, this defensive behavior has proven difficult to describe at the molecular level. Exceedingly few model systems have been utilized to characterize the potential interactions between what researchers estimate to be at least four million insects and 230,000 flowering plant species. Moreover, highly active plant defense signals can occur at trace levels, too small to easily detect or isolate.

Still, scientists have determined that insect herbivory, mechanical damage, and pathogens such as bacteria and fungi can all set off a variety of peptide warning signals in plants, which respond by increasing phytohormones, particularly ethylene, jasmonic acid, or salicylic acid, that regulate defensive responses. But which peptide signals act as alarms—and how"

To address those questions, Dr. Eric Schmelz at the United States Department of Agriculture's Center for Medical, Agricultural and Veterinary Entomology operated by the U.S. Department of Agriculture's Agricultural Research Service in Gainesville, Florida, led a research team that spent three years systematically analyzing the biochemical response of cowpea (Vigna unguiculata), a legume, to herbivory and oral secretions of fall armyworm (Spodoptera frugiperda), a general crop pest. During the extensive project, the researchers conducted over 10,000 leaf bioassays, testing for plant phytohormone production after exposure to successively fractionated insect oral secretions, among other experiments. Painstakingly collected just a few microliters at a time, the team tested approximately one full liter of caterpillar secretions.

As previously reported, the scientists identified and isolated an 11 amino acid peptide, inceptin, that plays a pivotal warning role in cowpea plants being attacked by the fall armyworm. Inceptin is part of a larger, essential enzyme, chloroplastic ATP synthase, in plants. When the fall armyworm feeds on cowpea, the insect ingests ATP synthase and breaks it down, releasing inceptin, which then becomes part of the armyworm's oral secretions. When the worm next feeds on cowpea, trace amounts of inceptin recontact the wounded leaf and alerts plants to generate a burst of defensive phytohormones.

In the June issue of *Plant Physiology*, Schmelz and his USDA collaborators, including Sherry LeClere, Mark Carroll, Hans Alborn, and Peter Teal, take the analysis further. They confirm inceptin's role as the dominant (and most stable) peptide in the cowpea's defense to fall armyworm. In addition, the researchers identify two related but less abundant peptide fragments (Vu-GE+In and Vu-E+In) that provoke similar defense responses in cowpea and a third (Vu-In-A) with no apparent effect. They also show that inceptin-related peptides spark a consistent, sequential cascade of phytohormone increases in cowpea, beginning with jasmonic acid, followed by ethylene and, lastly, salicyclic acid. Finally, the researchers determine critical features of inceptin's structure: To work as a plant defense signal, the peptide must contain a penultimate C-terminal aspartic acid, though the structure is considerably more flexible at its N-terminal. Notably, a number of the general characteristics of inceptin are similar to another known plant defensive peptide signal, systemin.

The new work challenges researchers to reconsider plant-insect interactions. "Scientists searching for defense elicitors need to realize those elicitors may not be synthesized by—or even exist within—the insect pest species," Schmelz said. "Instead, the attacker's proteases may interact with the host proteins, generating an elicitor." Building on this work, Schmelz is now recruiting a post-doctoral scientist to help the team biochemically purify and identify the inceptin receptor from legumes.

Source: American Society of Plant Biologists